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by

Ove A. Pedersen, FFS

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The Herring Fishery Marketing Association (FFS) provides raw materials for all types of fish feed. The main products are NorSeaMink and NorSalmoil. NorSeaMink is a special meal which is used as a protein source in dry feed, soft pellets, mixed feed and ensilage. NorSeaMink is mainly produced from winter capelin but also from blue whiting, Norway pout, mackerel, herring and others. In addition to some 70 per cent protein and some 10 per cent fat, the fish meal also contains a number of important nutrients and trace elements.

NorSeaMink LT is a relatively new special meal produced at low temperatures. The LT meal has proven advantageous in several respects in particular with regard to feed for fry.

NorSalmOil contains only capelin oil, and as a fat additive for dry feed, it controls the market. It is also used as a fat additive in soft pellets, mixed feed and ensilage when these raw materials are too lean to provide properly energy-balanced feed. The fatty acid composition of the capelin oil makes it particularly suitable as a fat source for farmed salmon.

NorSalmOil also contains an antioxidant which makes it possible to store it for a comparatively long time without significant oxidation (turning rancid).

The natural feed Naturell, which is a feed frozen at sea, mainly consists of sea-frozen Capelin. However, other fish species such as brisling, herring and

mackerel are increasingly in demand as fish feed. Recently, blue whiting has been in demand to compensate for the lack of pollack waste.

Natural silage - whole fish ensiled at sea - has successfully been established in the market and is competing with silage from filet waste, trims, entrails and other fish products because of its freshness and high nutritional value.

The FFS sells natural silage from the following fish species:

	Percentage fat
Capelin:	7 - 21
Herring:	12 - 5
Brisling:	8 - 20
Mackerel:	20 - 30
Norway Pout:	3 - 8
Blue whiting:	2 - 7
Tobis:	7 - 9

Since the beginning of fish breeding, FFS has been selling fish feed and raw materials for fish feed.

In 1984, FFS sold over 11 million hectolitres of fish, including the following:

1 870 000 hectolitres of special fish meal, fish oil, NorSeaMink and NorSalmOil.

121 000 hectolitres of fish feed frozen at sea - the natural feed called Naturell.

29 000 hectolitres of sea ensilaged roundfish - Natural Silage (Naturensilage)

5 000 hectolitres of fresh fish delivered for salmon feed.

Accordingly, FFS is Norway's largest supplier of raw materials for fish feed.

This article will discuss some of the more important aspects of the various raw materials. These raw materials are used in dry feed, soft pellets mixed feed and silage. How much of the various substances the salmon can absorb depends upon the treatment of the raw material and the form in which the raw material is served to the salmon. Factors such as storage time, storage conditions, additives, content of decomposition enzymes, heat treatment and physical consistency are all important.

VITAMINS

Although the vitamin contents of the various raw materials to some extent are known, they vary greatly depending on the factors above, to such an extent that it is difficult to provide values which would apply for different conditions. However, some confidence in the vitamin content can be obtained from the fact that the producers of dry feed and meal add the same vitamins and minerals in approximately the same amounts, irrespective of whether the meal is pelleted and sold as finished dry feed or if the meal is sold for mixing in soft pellets, mixed feed or silage. The dosage of vitamins and minerals depends, however, on the content of dry substances (which in turn should reflect the energy content) in the finished meal. It is therefore important that the minimum mixing percentage recommended by the producer is maintained for the various types of feed. Should a lower mix ratio be desirable in a certain type of meal, one should compensate by adding a vitamin concentrate.

RELEVANT DATA

The data presented in the tables at the end of this article were obtained from the Fisheries Directorate's Vitamin Institute. Researcher Finn Utne was responsible for the analytical work. The data presented are chosen from a

series of articles written by Finn Utne. These articles were published in Fiskets Gang during 1976 under the title of "Nutritional components and feed values of trash fish and industrial waste". The values in the table are average values from "average fish". This means that the actual values will vary depending on time of the year, the age of the fish, its sexual maturity, etc.

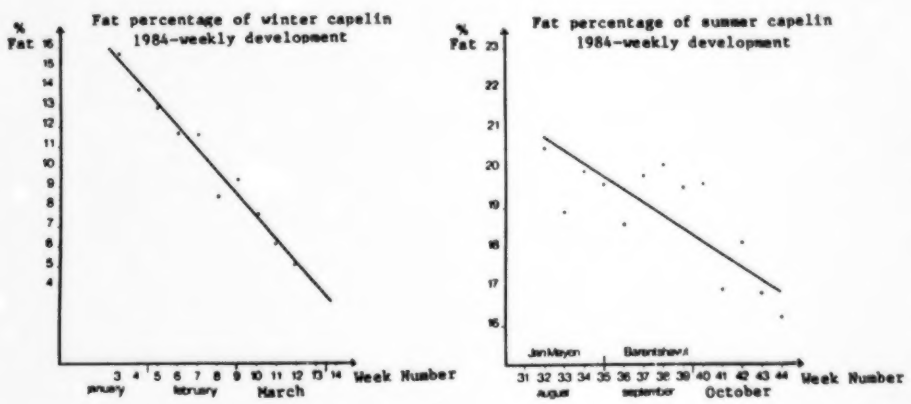
PROTEINS AND AMINO ACIDS

Amino acids are relatively small nitrogenous compounds which, when bound together in long chains, are called proteins. Thus, proteins comprise mainly amino acids. Even if there are several thousands of proteins, only twenty amino acids dominate the structure of all these myriads of proteins. Ten of these amino acids cannot be produced by the salmon itself, and it is therefore of vital importance that the salmon receive sufficient quantities of these additives in the feed. These ten amino acids are called essential amino acids. However, various groups of organisms and nutrients can differ greatly as far as the composition of amino acids in their proteins is concerned. One group may have very little of some amino acids while another group may have a great need for these. This means that even if the feed contains sufficient proteins measured in per cent of the dry substance, the salmon may nevertheless receive too little of one or more important amino acids. If we compare amino acids composition for the various fish species in table 2 with the calculated need for the salmon (see references a and b), we can observe that these fish species contain a sufficient amount of all essential amino acids to meet the needs of the salmon.

FATS AND FATTY ACIDS

Fat is also comprised of various compounds including so-called fatty acids. In the industrial context, fat is called oil when it is liquid at temperatures lower than plus 20°C.

Some fatty acids are more important than others. Fish fats are particularly rich in unsaturated fatty acids. As with the essential amino acids, there are also essential fatty acids, that is, fatty acids which the salmon cannot itself produce but which it must receive through its feed. Fatty acids of the linolenic type (n-3 fatty acids) are essential for the salmon (18:3 n-3, 20:5 n-3, 22:5 n-3 and/or 22:6 n-3). The unsaturated fish fat or fish oil may contain up to 30% n-3 fatty acids. It can therefore be assumed that the salmon's need for essential fatty acids can be met since dry feed contains some 1% n-3 fatty acids. As long as fish or fish oil is used as a fat source in the salmon feed, there should be no danger that the salmon will not receive the essential fatty acids whether the feed is dry, soft, wet or acid.



MINERALS AND TRACE ELEMENTS

The requirements for minerals and trace elements have not been specifically studied for salmon. Some approximations are available for fish in general, but this, in the opinion of many, is not directly transferable to salmon. Table 4 presents the values which Finn Utne established when he investigated the contents of some of the important minerals and trace elements.

There has recently been much talk about selenium in the context of the "Hitra-disease". It has been claimed that salmon requires some 0.4 mg of selenium per kilogram of dry feed. If one considers the selenium content in fish raw materials, it can be seen that these more than cover the needs of the salmon. However, to what extent the various feed production methods influence the salmon's ability to absorb and use substances such as selenium remains to be discovered.

Table 1: Data for the "average fish" referred to in tables 2, 3 and 4.

	Capelin	Brisling	Herring	Mackerel	Blue whiting	Norway Pout
Dry Substance % . . .	25.6	29.5	36.6	36.3	24.7	27.6
Raw protein %	13.4	16.4	16.3	19.0	17.2	16.5
Raw fat %	10.1	11.3	17.9	17.3	4.9	8.1
Ashes %	1.9	2.8	2.1	1.9	3.1	3.1
Average weight, g. .	18.9	10.2	88.7	-	17.6	27.6
Average length, cm. .	14.7	10.5	21.3	-	29.8	14.8

Table 2: Amino acids in per cent sign of total protein.

Amino acids	Requirement a	Requirement b	Capelin	Brisling	Herring	Mackerel	Blue whiting	Norway Pout
Asparagic acid*	2.2	3.4	10.07	8.80	9.00	8.81	9.72	10.63
Threonine			4.63	4.17	4.07	4.56	4.04	4.76
Serine			4.50	4.27	3.87	4.40	4.45	4.57
Glutamic acid			12.73	12.57	12.67	11.99	12.97	14.03
Proline			4.47	3.40	-	4.08	3.82	2.90
Glycine			5.58	5.40	5.90	5.90	5.72	6.40
Alanine			5.94	5.70	5.70	5.91	5.79	6.40
Valine*	3.2	3.1	5.19	4.53	4.30	4.74	4.55	4.60
Cystine		0.9	0.72	0.70	-	0.98	0.71	0.87
Methionine*	4.0[1]	1.8	2.99	2.17	3.13	2.37	2.69	2.53
Isoleucin*	2.2	2.4	4.31	3.73	3.87	4.18	4.16	4.07
Leucin*	3.9	4.4	7.87	7.00	7.50	7.51	7.31	7.30
Tyrosine		2.1	3.65	3.20	3.23	3.31	3.33	3.20
Phenylalanine*	5.2[2]	3.1	3.99	3.77	3.77	3.78	3.75	3.87
Lycine*	5.0	5.3	8.76	8.40	9.20	8.46	8.98	8.70
Histidine*	1.8	1.6	2.18	2.67	2.70	3.80	2.02	1.93
Arginine*	6.0	3.5	6.19	5.70	5.50	5.79	6.16	6.13
Tryptophan*	0.5	0.5	1.02	0.83	1.17	1.08	1.09	0.93
Taurine			1.15	0.57	1.07	0.92	0.79	1.73

* Essential, vital amino acids

1. Measured in the absence of cystin
2. Measured in the absence of tyrosin

Essential, vital amino acids

Source a: Mertz E.T. 1969. Aminoacid and protein requirements of fish. In: O.W. Neuhaus & J.E. Halver: Fish in Research, Academic Press 233-244. Requirement calculated for salmon fry, Pacific salmon.

Source b: Ogino, C. 1980. Requirements of carp and rainbow trout for essential aminoacids. Bull. Jpn. Soc. Sci. Fish 46: 171-174. The requirement calculated for rainbow trout.

Table 3: Fatty acids in % of total fat.

Fatty acids	Capelin	Brisling	Herring	Mackerel	Blue whiting	Norway Pout
14:0.....	6.5	4.9	8.5	7.5	4.2	5.6
16:0.....	10.2	16.3	14.3	13.9	12.0	12.3
18:0.....	1.3	3.2	1.0	2.1	2.0	2.7
Saturated.....	18.1	24.4	23.8	23.5	18.2	20.6
16:1.....	9.3	6.5	6.1	5.2	5.3	4.7
18:1.....	14.0	18.2	9.7	12.2	15.8	13.8
20:1.....	12.7	5.9	15.5	12.4	9.6	10.2
22:1.....	10.6	9.5	21.8	18.4	11.0	11.7
Monoesters.....	46.6	40.1	51.2	48.2	41.7	40.7
18:4.....	5.3	1.7	3.0	3.5	4.8	4.3
20:5.....	10.0	9.5	5.1	5.1	9.2	8.2
22:6.....	9.6	13.7	6.5	8.5	14.9	14.3
Fully unsaturated....	24.9	24.9	14.6	17.1	28.9	26.8
18:2.....	1.2	1.7	1.4	1.9	1.0	1.2
18:3.....	0.7	1.5	1.5	1.7	0.9	1.2
20:2-3.....	0.4	0.8	0.6	0.6	1.0	0.6
20:4.....	1.7	0.6	0.4	0.6	1.9	2.6
22:2-4.....	0.6	0.6	0.7	0.8	0.6	0.6
22:5.....	0.6	1.1	0.8	0.7	1.0	1.0
Partially unsaturated	5.2	6.1	5.3	6.3	6.4	7.2
24:-.....	1.4	1.5	1.5	-	1.5	1.5
Various fatty acids	3.0	3.0	3.7	3.0	3.0	3.0

Table 4: Mineral and trace element content in the fish species as dry feed.

Minerals, g/kg	Capelin	Brisling	Hareng	Mackerel	Blue whiting	Norway Pout
Ca (Calcium).....	10.31	14.71	9.62	6.31	28.46	21.38
P (Phosphorous).....	22.00	18.98	18.31	13.11	22.19	18.77
Mg (Magnesium).....	1.56	2.03	0.98	0.99	1.90	1.88
Na (Natrium).....	5.55	11.66	3.36	4.33	7.17	5.18
K (Potassium).....	12.07	10.10	10.19	8.29	12.67	10.69
Trace elements, mg/kg						
Fe (Iron).....	63.67	78.31	62.02	68.15	114.57	93.48
Zn (Zink).....	65.23	80.00	49.73	49.72	54.66	48.19
Mn (Manganese).....	3.32	4.61	2.68	1.16	5.67	3.51
Cu (Copper).....	3.40	3.86	2.51	3.36	5.30	4.67
Pb (Lead).....	1.05	0.31	0.43	0.28	0.97	0.87
Cd (Cadmium).....	0.25	0.20	0.13	0.02	0.14	0.09
Co (Cobolt).....	0.05	0.03	0.02	0.39	0.03	0.05
Hg (Mercury).....	0.10	0.19	0.14	0.08	0.26	0.11
As (Arsenic).....	9.61	10.81	6.01	1.52	19.31	14.06
Se (Selenium).....	4.41	1.22	1.17		3.68	1.70